

REPORT OF THE COMMITTEE ON TYPIFICATION OF
SPECIES OF PROTOZOA. Z.N.(G.) 185

By R.V. Melville (Chairman) (*Secretary, International Commission on Zoological Nomenclature, London*)

1. *Establishment, Terms of Reference and Membership of the Committee.*

1.1. The committee was established by the International Commission on Protozoology at the Fifth International Congress of Protozoology, New York, June 1977, as a consequence of the action of a group of German workers who had rejected early names for species of *Sarcocystis* and related genera. It was clear that their action was rooted, at least in part, in the impossibility of designating meaningful types for the species concerned under the provisions of the International Code of Zoological Nomenclature, and that changes in the rules governing types in the species group (Code Chapter XVI) would be needed to meet this problem.

1.2. The terms of reference of the committee were: "To study the problem of typification of species of protozoa and to report to the International Commissions of Protozoology and Zoological Nomenclature by June 1978". The report is a little later than ordered because of the difficulty in arranging a meeting of the Committee.

1.3. The members of the committee (apart from the Chairman) were: R.S. Bray (*Medical Research Council, London*), J.O. Corliss (*University of Maryland, U.S.A.*), J. -M. Doby, (*University of Rennes, France*), P.C.C. Garnham (*Imperial College Field Station, Ascot, U.K.*), N.D. Levine (*University of Illinois, U.S.A.*) and F.C. Page (*Culture Centre for Algae and Protozoa, Cambridge, U.K.*).

2. *Methods of Work of the Committee.*

2.1. The committee worked by correspondence from 9 September 1977 to 7 June 1978 and defined the problems to be studied with increasing clarity and mutual understanding. However, it became clear at an early stage that agreement on positive proposals would only be reached if a meeting of the committee could be arranged. Professor Garnham and Professor Levine accordingly approached the Fogarty International Center, National Institutes of Health, Bethesda, Maryland, U.S.A. for help with the organisation and funding of such a meeting.

2.2. In the event, our meeting was sponsored jointly by the Fogarty Center, the Center for Disease Control, and the National Institute for Allergy and Infectious Diseases, and was held at the Fogarty Center on 26–28 June, 1978. Dr. Victor Sprague (*Chesapeake Biological Laboratory*) attended by invitation. During its meeting the committee consulted Dr. Richard Carter (*National Institutes of Health*), Dr. P. -M. Daggett (*American Type Culture Collection, Rockville, Maryland*), Dr. H.G. Sheffield (*National Institutes of Health*) and Dr. C.W. Sabrosky (*President, International Commission on Zoological Nomenclature*). The committee is grateful to these consultants for their advice freely given, but takes entire responsibility for this report.

2.3. The Chairman and members of the committee wish to record their sincere gratitude to the sponsors for their generous and efficient help in making the meeting possible. Without it, our work could not have advanced so far or so fast, nor could our conclusions be put forward with the confidence that we feel in those presented herein.

3. *The Agenda of the Committee Meeting.*

3.1. Professor Levine, in drawing up the prospectus for the meeting, had identified six topics for discussion. The committee examined these in the following order:

1. The use of collective group names in the protozoa
2. Specifying type specimens of species of protozoa with two or more stages in their life cycle
3. Specifying type specimens of species of protozoa among multiple specimens in the same preparation
4. Specifying type specimens of species of protozoa of which individuals cannot be preserved
5. Designating suitable depositories for type specimens of species of protozoa
6. The *Sarcocystis* problem.

3.2. Although it was the *Sarcocystis* problem that had led to the establishment of the committee, so that it would have been normal to have considered it first, it was deferred because of a letter to the International Commission on Zoological Nomenclature then being prepared by Professor J.K. Frenkel (*University of Kansas Medical Center, U.S.A.*) on his own behalf and on behalf of the German workers mentioned below. Copies of this letter reached the committee on the last day of the meeting and it is referred to in the final section of this report.

4. The Use of Collective Group Names in Protozoa.

4.1. The major achievement of the German group (Professor M. Rommell, *Veterinary School of Hanover, B.R.D.*, Dr. A.O. Heydorn, *Free Univeristy of Berlin, B.R.D.* and their collaborators) was to have shown that, at least in some cases, herbivorous mammals thought to be parasitised by a single species of *Sarcocystis* with a simple life cycle, were in fact parasitised by two or more species, and that these species passed through a second, previously undetected or unrecognised, sexual cycle, each in a single predator species. Development of their original work led to the recognition of a number of genera for the reception of species originally described in *Sarcocystis*. At the same time, the German workers suggested that specific names (some with claims to priority) based on single stages should be rejected; they proposed replacement names based on a combination of the generic names of the intermediate and definitive hosts. This was, of course, contrary to the provisions of the International Code of Zoological Nomenclature in general and to the Law of Priority in particular. (It may be mentioned that no evidence of a complex life cycle is yet available for the great majority of the 80 or more named species of *Sarcocystis*).

4.2. The term "collective group" has grown up through long usage among helminthologists. It denotes a taxon at the level of the genus to which are referred species that can be distinguished as such, but whose generic position is not clear. These are usually species known only from a single, immature, stage of a complex life cycle, and it is assumed that when the other stages are known it will be possible to assign each species to its correct genus. Collective groups thus serve as holding stations for unallocated species and, as such, require no type species (Code Article 42c). It seemed possible, *a priori*, that collective groups might also be used in the protozoa, for example for species of *Sarcocystis* known only from muscle cysts in the herbivorous intermediate host.

4.3. In considering this possibility, the committee noted that the name *Microsporidium* in the Phylum Microspora had come to be used as a group name. It noted also that the relationship between generic names and collective group names is not fully clarified in the Code. The process whereby names originally proposed for genera (of which the type species may have been fixed, originally or subsequently) come to be accepted as collective group names is by no means clear. Furthermore, there is room for argument as to how far a species held in a collective group because it is certain that its

life cycle is incompletely known is biologically analogous to a species whose life cycle is fully known and whose generic position can be determined. The German work has shown that individuals originally placed in a single species known only from a single stage may have to be distributed among two or more species (which may be placed in more than one genus) when the life cycles are worked out. Even among free-living protozoa, recent work has shown, for example, that individuals formerly referred to the "collective" species "*Paramecium aurelia*" must be distributed among a dozen or more species, although their generic position is not in doubt.

4.4. For these reasons the committee feels unable to recommend the unrestricted application of collective group names to the protozoa and notes the many possibilities of an open nomenclature for expressing various degrees of uncertainty. It therefore addresses the following recommendation to the International Commission for Protozoology:

The collective group approach is not excluded in protozoology. It is well established in certain areas (e.g. *Microsporidium* among the Microspora), but should be applied in other fields only with caution, and the use of an open nomenclature is generally to be preferred (e.g., "*Plasmodium sensu lato*" and "*Plasmodium sensu stricto*", "*Haemogregarina s.l.*" and "*Haemogregarina s.s.*"). Should a collective group name be used, it should be different from that of a genus whose type species has been fixed under the Code, e.g. *Sarcosporidium* rather than *Sarcocystis* or *Isospora*.

The Commission is asked to draw this recommendation to the attention of protozoologists, and especially of teachers, editors and referees in protozoology.

5. Types of species with two or more stages in their life cycle.

5.1. The problem of specifying types of species with two or more stages in their life cycle was the most difficult confronted by the committee. It amounted to specifying what, in such protozoa, could fulfil the function served by a holotype in most metazoan groups. Because of the complexity and diversity of the life cycles of parasitic protozoa, it was more than a mere generalisation of the *Sarcocystis* problem. In addition, the committee's terms of reference did not exclude the free-living protozoa, in which also the life cycle may be complex.

5.2. The committee had first to clarify its understanding of the function of a type. This it took to be to serve as a permanent

standard of reference for verifying applications of a name (Code Article 61). Where species (and subspecies) are concerned, the Code does not require that a type be designated when a new taxon is established; but it does require that if a type is designated (originally or subsequently), it must consist of a single individual. Since no single individual can fulfil the function of a type as herein defined in protozoa with complex life cycles (especially the parasitic forms), it is clear that the relevant provisions of the Code (Articles 61, 72) actually prevent the stabilisation of nomenclature by means of type designations for species. The committee quickly realised that some means had to be found of designating multiple types, consisting of more than one specimen, for certain species-group taxa, while respecting as far as possible the logical requirement that a type be objectively unitary.

5.3. This problem appeared to divide at once into two parts, one related to species that could be expected to consist of a series of individuals which would either form part of a clone, or represent only a single stage of a life cycle, and the other to species that could only be adequately represented by a series of exhibits, representing some or all of the differing stages of the life cycle. In the first case, a single preparation displaying numerous individuals (perhaps a million in the *Microspora*) can serve as a type. The second case, however, is more complex.

5.4. Of the 7 phyla into which the protozoa are currently divided, 6 include parasitic forms. The range of diversity is thus very wide. It may be that in some families and orders of parasites, genera and even species can be distinguished at every phase in the life cycle; but it does not necessarily follow that such a species can be typified by a unique holotype, since, at some stages, the similarities between it and its relatives may appear more striking than those between its own successive stages. In other groups, some stages may be indistinguishable at specific, generic, or even at higher levels (coccidian oocysts provide an example). Yet it would be shortsighted to omit representation of such stages in a multiple type, since the presence of (for example) an oocyst stage in the life cycle is itself an important characteristic. Moreover, developments in technique may allow distinctions to be drawn in future where they cannot be drawn now. This, however, does not affect the principle of the multiple type as such.

5.5. The committee considered at some length how to reconcile these constraints with the opposite constraint that the type of a

species must be a single specimen. It concluded that a multiple type must consist of directly related individuals — that is, of individuals taken at one stage in the life cycle and cycled under controlled conditions through the various host species until it is possible to draw off and preserve samples of each stage from a single strain which, itself, can continue to exist. The committee recognises the difficulty of attaining this standard and accepts that many known species, and many still to be discovered, will not be typified for many years. It also accepts the implication that many species cannot, in future, be typified when first established. At the same time it remarks, first, that typification of species is not a mandatory requirement of the Code and, secondly, that protozoologists have not usually been habitual designators of types for their species. The committee firmly asserts that the fact that a species cannot be (or, in the past, has not been) typified when it is established is no reason for rejecting its name when advances in knowledge make typification a practical possibility.

5.6. At this point it becomes clear that a new term must be proposed to designate a multiple type. The term must be capable of bearing the prefixes “holo-”, “para-”, “syn-”, “lecto-” and “neo-” in the same way as the word “type” does. It is therefore desirable to coin a term of Greek derivation, and the committee proposes “hapantotype”, of which the first part is derived from the Greek *ἄπας, ἀπαντος* meaning “together”. This is to signify that a hapantotype is made by putting together the several components needed to provide the standard of reference required by users of the name. These components are to be deemed inseparable. Thus, while a series of syntypes and a hapantotype each consists of a number of specimens, a lectotype can be designated from the former, but not from the latter. A “lectohapantotype”, if one were designated, would only be valid if it included all the components required for a “holohapantotype”.

5.7. A hapantotype will thus consist of two or more preparations illustrating differing stages in the life cycle of a species. It may, however, be necessary in some instances to go further than this. In many parasitic forms, the lesions developed in some part of the host provide crucial evidence for specific differentiation. This evidence (“work of an animal” in the sense of the Code), when it is directly associated with the parasite itself (e.g. the filaments on erythrocytes infected with *Nycteria medusiformis*; enlarged nuclei of liver cells of hosts of *Hepaticystis*) will in any case form part of the hapantotype. But if no parasite is present in the lesion (as in the aftermath of *Eimeria necatrix* infections), the latter cannot form

part of the hapantotype. In cases in which the duration of stages of the life cycle is important in specific differentiation, this character may be represented in the hapantotype by a series of preparations taken at appropriate intervals.

5.8. The committee also considered whether material prepared and preserved by modern methods should be admissible in contributing to hapantotypes. For example, in some species of protozoa, electron microscope preparations might be considered to be covered by the provision (in the draft Third Edition of the Code) that part of a specimen may form the type of a species. We refrain, however, from adding sections prepared for the electron microscope to the list of possible components of hapantotypes, for two reasons: first, because in the current state of knowledge, there is doubt as to the durability of such material; secondly, because an electron micrograph shows only a very small fraction of the individual, and the orientation of the section photographed is critical. We therefore leave it to future workers to make proposals to the Commission when techniques have advanced further.

5.9. Frozen specimens in liquid nitrogen are a possible source from which hapantotypic material might be taken for fixation and deposition in a collection. The committee was advised, however, that there are serious hazards in using frozen material as a sole source. When (as is usual) several ampoules of a given species are stored together, there may be very wide variation between ampoules in the number of cells present and in their viability. Risks also arise from the presence of mixed populations and from the selective effect of freezing. Such material can therefore at present play only a supplementary role in constructing a hapantotype. It is for individual workers to decide for themselves whether or not their material is suitable for typification by frozen specimens.

5.10. The committee also recognises the value of biochemical and immunological characters (e.g., isoenzymes) in determining species. If the molecules used in this way can be preserved (as in paper chromatography) they may form part of a hapantotype, provided they are taken from the same directly related individuals as the other components.

5.11. The committee concluded its discussion of the point by proposing an addition to Article 72b of the Code to make provision for hapantotypes. (Because that section, in the draft Third Edition of the Code, is already complicated, we suggest that it be broken

down into subsections for ease of reading, and therefore present the whole section here.) We formally ask the International Commission on Zoological Nomenclature to amend Article 72b of the Code as follows:-

(b) Meaning of the term "type" in the species group.- In the provisions of this Chapter the term "type" may mean any of the following:

- (i) an animal;
- (ii) part of an animal;
- (iii) a colonial organism existing in nature as a single entity, or part of such an organism;
- (iv) in fossils, any of the objects specified in (i) to (iii), or a natural replacement, a natural cast, or a natural impression of any of them;
- (v) in certain extant species of protozoa, if the provisions of (i) to (iii) cannot be applied, either
 - (1) a number of individuals assumed to be directly related and presented in a single preparation, or
 - (2) a suite of preparations of directly related individuals or parts of individuals representing differing stages in the life cycle (hapantotype);

Recommendation.- Whenever possible, in light-microscope preparation, the locations of individuals considered by the zoologist establishing a new species-group taxon to be of crucial importance in demonstrating his concept should be distinctly marked.

(vi) in the special case of Section c(i) of this Article, the work of an animal.

[Note. The proposal concerning Article 72b (v) of the Code was discussed at a meeting held during the Fourth International Congress of Parasitology in Warsaw in August 1978. The following amended version was there put forward:

- (v) in certain extant species of protozoa, when necessary in the interests of stability of nomenclature, and if (but only if) the provisions of (i) to (iii) of this Section cannot be applied, either
 - (1) a number of preserved, directly related individuals presented in a single preparation, or
 - (2) a suite of preserved preparations of directly related individuals or parts of individuals representing differing stages in the life cycle (hapantotype).]

6. *Specifying type specimens of species of protozoa among multiple specimens in the same preparation.*

6.1. This question hardly seems to arise in the cases covered by Article 72b (v) (1), since all the cells in such a preparation are assumed to be of equal value. In a hapantotype, however, it may well be that a cell will show progressive changes during its passage through a single stage, and that certain cells in each preparation may show these particularly well. We hope we have covered this point in the Recommendation we have added to Article 72b.

7. *Specifying type specimens of species of which individuals cannot be preserved.*

7.1. The committee takes this to be a transitory problem. The fact that methods have not yet been devised for preserving material of certain species is, we feel sure, a temporary technical problem to which the solution will soon be found. This is particularly relevant to the preservation of oocysts of Eimeriina, the suborder that includes *Sarcocystis*, which caused our committee to be set up.

8. *Designating depositories for types of protozoa.*

8.1. The preservation of type specimens of protozoa poses problems not met in all animal groups. Depositories should, first, meet the criteria of Recommendations 72A and 72D of the Code. In addition, material must be kept at a constant temperature, in controlled atmospheric conditions, and in the dark. Other criteria are demanded by certain groups. We recommend that the International Commission on Protozoology compile a list of suitable institutions and, to the best of its ability, encourage the deposition of types (including hapantotypes) in institutions included in this list. Paratypic material should be deposited in other listed institutions as a measure of security.

9. *The Sarcocystis problem.*

9.1. Since this is the subject of a formal approach to the Commission by Professor Frenkel and his colleagues, it should be treated as *sub judice* until a ruling is published. In particular, the Chairman of the committee, as Secretary of Commission, abstains from expressing any view at this point. It is, however, certain – and some members of the committee have stated so publicly – that the German workers were wrong to reject specific names of long standing as they did. When they found that there were at least three species of *Sarcocystis* in cattle instead of one, their proper course would have been to apply the Law of Priority and arbitrarily restrict the oldest available name to one of those species.